Chapter 4. Water Quality Monitoring 2004-2005

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Introduction

The monitoring program for the Grassland Bypass Project (GBP), including water quality monitoring, is described in detail in Compliance Monitoring Program for the Use and Operation of the Grassland Bypass Project, Phase II (USBR et al., 2002). This chapter provides a summary of the water quality monitoring program, modifications to the plan for the third and fourth years of operation of Phase II of the GBP (January 1, 2004 to December 31, 2005), and water quality trends observed during this period. Detailed water quality data of individual monitoring stations will not be provided in this summary, as the San Francisco Estuary Institute (SFEI) has presented this information in annual narrative and graphical summary reports (SFEI, 2005 and 2006).

Monitoring Program

The Central Valley Regional Water Quality Control Board (CVRWQCB) has an on-going water quality monitoring program related to regulatory activities for agricultural subsurface drainage from the Grassland watershed. The water quality monitoring program for the GBP is an adaptation of the CVRWQCB monitoring program. The CVRWQCB conducts most of the water quality sampling. The Panoche Water District (under contract with the San Luis & Delta-Mendota Water Authority; SL&D-MWA) assists the CVRWQCB by collecting samples at Stations A, J, K, L2, and M2. Samples are transferred to and processed by the CVRWQCB and analyzed by its contract laboratories. The CVRWQCB conducts quality assurance (QA) reviews of the data before submitting them to the SFEI for reporting.

Monitoring Objectives

The water quality monitoring program was designed to provide data for evaluating compliance with commitments in the Project Waste Discharge Requirements (CVRWQCB, 2001), the Use Agreement, and associated documents. The commitments include

- Monthly and annual selenium load limits on discharges
- No degradation of the San Joaquin River water quality relative to the pre-Project-condition
- Cessation of discharge of agricultural subsurface drainage to the wetland channels

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- Management of flows in the San Luis Drain (SLD) so as to not mobilize channel sediments

The Monitoring Program was also designed to verify the validity of assumptions expressed in documents associated with the GBP. The assumptions include:

- The GBP is expected to result in selenium concentrations less than 2 µg/L in approximately 93 miles of wetland water supply channels.
- The increased frequency of exceeding selenium water quality objectives in Mud Slough (north) will be offset by a reduction of exceedances in Salt Slough.

In addition, the Monitoring Program was intended to provide data to be used to assess spatial and temporal trends in water quality parameters of concern and to characterize habitats in which biological samples were collected.

Sampling Locations

Monitoring was conducted in four areas; the SLD, Mud Slough (north), the San Joaquin River, and the Grassland wetland water supply channels, including Salt Slough. Table 1 summarizes the Monitoring Program, and sampling locations are depicted in Figure 2 in Chapter 1.

Frequency of Sampling

The frequency of sampling is outlined in Table 1. Weekly composite samples were collected at Station A (inflow to the SLD). Daily composite samples were collected at Station B (discharge from the SLD), and at Station N (San Joaquin River at Crows Landing). At Station A, daily samples were composited into a weekly sample to be used along with continuous flow data to calculate weekly selenium load inflow to the SLD. At Station B, daily composite samples along with continuous flow data were used to calculate daily selenium load discharge to Mud Slough (north). At Station N, daily composite samples were collected to allow the CVRWQCB to calculate loads and evaluate progress toward compliance with Basin Plan water quality objectives. The compliance date at Station N for the selenium water quality objective (5 µg/L 4-day average) during normal and wet years is October 1, 2005, and during critical years is October 1, 2010 (CVRWQCB, 1998a) (Table 2). Since the objective is based on a 4-day average concentration, consecutive daily samples are required at this station. The remaining stations were sampled on a weekly basis.

Sampling Methodology

Three types of sampling techniques were utilized, depending on the frequency of sampling and data needs: auto-sampler, mid-channel depth-integrated, and grab sample from channel bank. Auto-samplers were used to collect daily and weekly composite samples because of the remoteness of the station and frequency of sampling. At Stations A, B, and D, structures such as a bridge or platform over the channel permitted the collection of mid-channel, depth-integrated samples. At other stations, a grab sample was collected from the stream bank. With respect to stream hydrology, lateral and vertical homogeneity was assumed for dissolved constituents at all sampling stations.

Modifications to the Water Quality Monitoring Program

During the Phase I of the GBP a number of issues were resolved with respect to the water quality monitoring program. These modifications and clarifications to the monitoring program are discussed in the previous Annual Reports (USBR, 1998 and SFEI, 1999, 2000, 2001, 2003, and 2004).

Prior to August 2003, nutrient samples were collected at Stations B and D as part of a research program external to the GBP water quality monitoring program. In an effort to minimize program costs, the DCRT agreed to incorporate that data into the water quality monitoring program. Frequently, due to reasons outside of the control of the DCRT, these data were unavailable. In August 2003, in an effort to prevent this loss of data, routine collection of nutrient samples at Stations B and D was assumed by the CVRWQCB.

No other changes to the water quality monitoring program occurred during 2004 or 2005.

Water Quality Trends

Detailed water quality data for each monitoring station are presented in the Grassland Bypass Project Annual Narrative and Graphical Summary Reports, January 2004 to December 2004 (SFEI, 2005) and January 2005 to December 2005 (SFEI, 2006). Thus, this presentation will be limited to major water quality trends and findings for the third and fourth years of operation of Phase II of the GBP. Of primary interest are selenium concentrations in the San Joaquin River and water quality trends in Mud Slough (north). Also of interest are sporadic exceedances in the wetland channels of selenium water quality objectives established in the Water Quality Control Plan for the Sacramento/San Joaquin River Basins.

<u>San Joaquin River</u>

The Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Basin Plan) contains a schedule for compliance with the 5-µg/L (4-day average) selenium water quality objective and performance goals. The compliance date is either October 1, 2005 or October 1, 2010, depending on water year type (wet, dry, etc.) (Table 2). Compliance with selenium water quality objectives and performance goals specified in the Basin Plan is measured at Station N.

Figures 1 and 2 depict selenium concentrations in the San Joaquin River at monitoring Stations G (weekly grab), and N (4-day average) for 2004 and 2005. Station G is located at Fremont Ford, upstream of the Mud Slough (north) inflow to the San Joaquin River. Because this station is located upstream of drainage discharges from the GBP service area (except during flood events when drainage is occasionally routed to Salt Slough), selenium concentrations are generally low. Station N is located downstream of the GBP discharges conveyed by Mud Slough (north) and the Merced River inflow to the San Joaquin River. Merced River inflows dilute the upstream selenium contributions (CVRWQCB, 2002a).

Table 2 depicts water quality objectives and performance goals for selenium in the San Joaquin River. The applicable performance goal for a dry water year (DWR, 2007), such as Water Year 2004, is an 8 µg/L monthly mean selenium concentration. Figure 3 depicts monthly mean selenium concentrations at Station N for 2004. Monthly mean selenium concentrations did not exceed 8 µg/L during 2004.

On October 1, 2005, a 5 µg/L 4-day running average water quality objective became effective in the San Joaquin River below the confluence with the Merced River for selenium for above normal and wet water year types. At the same time, a 5 µg/L monthly mean water quality objective became effective in the San Joaquin River below the confluence with the Merced River for selenium for critical, dry, and below normal water year types.

For the months of January through September 2005, the applicable performance goal for a wet water year such as Water Year 2005 (DWR, 2007), is a 5 µg/L monthly mean selenium concentration. Figure 4 depicts monthly mean selenium concentrations at Station N for 2005. Monthly mean selenium concentrations did not exceed 5 µg/L during this time.

For the months of October through December 2005, the applicable water quality objective for a wet water year such as Water Year 2006 (DWR, 2007), is a 5 µg/L 4-day average. Figure 2 depicts 4-day average selenium concentrations at Station N for 2005. The water quality objective was met continuously during the October through December 2005 timeframe.

The Basin Plan and the GBP Waste Discharge Requirements (WDRs) prohibit discharge of selenium from agricultural subsurface drainage systems in the Grassland Watershed to the San Joaquin River in amounts exceeding 8,000-pounds per water year. Compliance is measured at Station N. Calculations using daily selenium data, preliminary USGS flow data, and the load calculation methods found in CVRWQCB (1998b) indicate that the annual selenium loads measured at Station N during Water Years 2004 and 2005 were 4,078 pounds and 5,297 pounds, respectively; well below the 8,000-pound annual load limit for the Grassland Watershed.

<u>Wetland Channels</u>

Monthly mean selenium concentrations in the wetland channels during 2004 and 2005 are depicted in Figures 5 and 6. The monthly mean 2 µg/L selenium objective was met during all months of 2004 and 2005 in Salt Slough. Selenium concentrations slightly in excess of the monthly mean 2 µg/L objective were observed at Station L2 in March 2004 and March 2005.

During February 2005, heavy and persistent localized rainfall resulted in flows that exceeded the capacity of the Grassland Bypass Channel, and the Project was forced to make discharges though the Grassland Water District for a period of seven days (February 16 to February 22) (SLDMWA, 2005). As a result of this discharge, the monthly mean 2 µg/L selenium objective was exceeded at Station K during the month of February. The monthly mean concentration was 12.1 µg/L. Excluding the February 2005 stormwater diversions, the maximum observed monthly mean concentrations of 2.6 µg/L during 2004, and 3.5 ug/l during 2005, are substantially lower than pre-Project concentrations (CVRWQCB, 1998c).

Regional Board staff conducted preliminary investigations on the potential sources of selenium, which are detailed in two separate reports (CVRWQCB, 2000 and CVRWQCB, 2002b). In summary, primary sources of selenium to the channels were determined to be diversions from the 94,000-acre Drainage Project Area (DPA) (both stormwater flows and seepage from control gates), supply water, subsurface agricultural drainage from areas outside of the DPA, tailwater and local groundwater. To address the first source, diversions from the DPA, the Grassland Area Farmers (GAF) developed a stormwater management plan, and internal control gates were sealed. These actions appear to have controlled peaks of selenium previously observed during storm events.

Despite the stormwater management plan and control gate modifications made by the GAF, selenium concentrations have continued to sporadically exceed the 2 µg/l monthly mean selenium objective in the wetland channels, particularly from the pre-irrigation season through the early irrigation season (February and March). As a result of the continued elevated selenium concentrations, staff focused the ongoing investigations on potential selenium sources outside of the GBP area: supply water and subsurface agricultural drainage from outside of the GBP service area. Findings are currently under review and will be used to direct the ongoing investigation.

<u>Mud Slough (North)</u>

Selenium concentrations observed at Station D (Mud Slough (north) downstream of the SLD), during 2004 and 2005 are depicted in Figures 7 and 8, respectively. Water quality at Station D is dominated by the GBP drainage discharge. Selenium concentrations tend to be lowest from the fall through early winter (non-irrigation period) and highest during the irrigation period, which commences in mid winter (pre-plant irrigation) and lasts through the summer. During 2004, selenium concentrations at Station D ranged from 3.6 µg/L in October, to 48.9 µg/L in April. During 2005, selenium concentrations at Station D ranged from 2.9 µg/L in December, to 36.6 µg/L in May. For comparison purposes, the 5 µg/L (4-day average) selenium water quality objective, which applies October 1, 2010 for Mud Slough (north), is noted on Figures 7 and 8. Selenium concentrations regularly exceeded 5 µg/L at Station D. During 2004 and 2005, the observed concentration of selenium at Station C (Mud Slough (north) upstream of the drainage discharge) was always below 5 µg/L. The maximum observed selenium concentration of

1.4 µg/L was noted both in July 2004 (Figure 9) and August 2005 (Figure 10).

Boron Water Quality Objectives

Boron water quality objectives and monthly mean boron concentrations for Mud Slough, Salt Slough, and the San Joaquin River for 2004 and 2005 are presented in Tables 3 and 4. During 2004, exceedances of the 2.0 mg/L objective occurred at Station C in March and April, and at Station D from March 16 through September 15. The 1.0 mg/L objective was exceeded at Station N during February and March, and the 0.8 mg/L objective was exceeded at Station N during March and April and from June through September 15.

During 2005, exceedances of the 2.0 mg/L objective occurred at Station C in April, and at Station D from March 16 through September 15. The 1.0 mg/L and the 0.8 mg/L objectives were met continuously at Station N throughout 2005.

Sources of boron occur throughout the San Joaquin Basin and are not confined to the GBP service area (CVRWQCB, 2002a). The CVRWQCB is currently conducting a separate effort to control salt and boron loading to the lower San Joaquin Basin.

Molybdenum Water Quality Objectives

Molybdenum water quality objectives and monthly mean molybdenum concentrations for Mud Slough, Salt Slough, and the San Joaquin River for 2004 and 2005 are presented in Tables 5 and 6. The data indicate that molybdenum concentrations were below the 19.0 µg/L mean monthly water quality objective in Mud Slough, Salt Slough, and the 10.0 µg/L mean monthly water quality objective in the San Joaquin River throughout 2004 and 2005.

Nutrient Data

CVRWQCB staff collected nutrient samples at Stations B, C, D, G, and N. Available nutrient data for the San Luis Drain, Mud Slough (north), and the San Joaquin River are presented in Tables 7 through 16.

For comparison purposes, the Primary Maximum Contaminant Level (MCL) for nitrate in drinking water is 10 mg/L nitrate expressed as nitrogen (CVRWQCB, 2003). During 2004, nitrate levels in samples collected at Station B were above the MCL during the months of January through June, and for the first of two sampling events in July, with a maximum recorded value of 28.9 mg/L. Nitrate levels in samples collected at Station D were above the MCL for one of two sampling events during both the months of April and June, and below the MCL at Stations C, G, and N in all samples collected during 2004.

During 2005, nitrate levels in samples collected at Station B were above the MCL during the months of January through August, and during November and December, with a maximum recorded value of 33.1 mg/L. Nitrate levels in samples collected at Station D were above the MCL for one of two sampling events during both the months of March and May, and below the MCL at Stations C, G, and N in all samples collected during 2005.

Freshwater aquatic life criteria for ammonia are found in CVRWQCB (2003). The threshold value for ammonia toxicity is a function of both the temperature and pH of the ambient water from which the nutrient sample is collected. Temperature and pH field measurements were used to determine the ammonia toxicity threshold for each sample. Ammonia levels were below the toxicity threshold at Stations B, C, D, G, and N in all samples during 2004 and 2005.

Additional constituents (total Kjeldhal nitrogen, total phosphorus, and orthophosphate) continue to be collected to aid in the development of a TMDL for oxygen demanding substances in the San Joaquin River and future nutrient criteria.

Conclusions

Monitoring has shown that selenium concentrations in the San Joaquin River are a function of location in the River with respect to discharge points and tributary inflows, and of the assimilative capacity of the River. The lowest selenium concentrations in the San Joaquin River are upstream of Mud Slough (north) inflows. Mud Slough (north) inflow contains relatively high concentrations of selenium. The Merced River dilutes the San Joaquin River with respect to selenium. Selenium concentrations in the San Joaquin River at Station N, however, remain elevated relative to the background condition in the San Joaquin River at Station G.

The 2 µg/L monthly mean selenium water quality objective was exceeded in one of the wetland supply channels during 2004 and two of the channels during 2005. With the exception of the February 2005 diversions of agricultural subsurface drainage through the wetland channels, due to heavy localized rainfall, selenium concentrations were substantially lower than pre-project conditions for all sites.

A number of sources may contribute to the exceedances of selenium water quality objectives in the wetland channels, including agricultural subsurface drainage from areas outside the GBP being discharged to the channels upstream of the wetlands. Regional Board staff is conducting ongoing investigations focused on identifying sources of selenium that contribute to exceedances of the selenium water quality objective in the wetland supply channels. The results of these investigations are detailed in separate reports that are available from the Regional Board. The CVRWQCB is evaluating control actions to reduce selenium concentrations in the wetland channels.

For most of the year, the water quality of Mud Slough (north) downstream of the SLD inflow is governed by the GBP drainage discharge and fluctuates widely. Selenium concentrations tend to be lowest from the fall through early winter (non-irrigation period) and highest during the irrigation season, which commences in mid winter (pre-plant irrigation) and lasts through the summer. Selenium concentrations regularly exceeded 5 μg/L in Mud Slough (north) downstream of the SLD inflow. Upstream of the drainage discharge, the concentration of selenium was below 2 μg/L in all samples.

Boron water quality data from Mud Slough (north), Salt Slough, and the San Joaquin River were compared to applicable water quality objectives. Boron water quality objectives were exceeded at Mud Slough and in the San Joaquin River downstream of Mud Slough (north). The exceedances occurred during the pre-irrigation and irrigation seasons in the San Joaquin River and during the irrigation season in Mud Slough (north). Sources of boron occur throughout the San Joaquin Basin and are not confined to the GBP. The CVRWQCB is concurrently conducting a separate effort to control salt and boron loading to the lower San Joaquin Basin.

Molybdenum water quality objectives were met in Mud Slough (north), Salt Slough, and the San Joaquin River throughout 2004 and 2005.

Nitrate concentrations were frequently observed above the MCL in samples collected at Station B, and were the lowest during the summer months. Nitrate concentrations were occasionally observed above the MCL in samples collected at Station D during the months of March, April, and May. Nitrate concentrations were below the MCL at Stations C, G, and N in all samples collected during 2003. Ammonia levels were not observed above the ammonia toxicity threshold for any samples at any of the stations.

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Table 1. Summary of Water Quality Monitoring Plan

Location	Site	Description	Purpose	Analytical Parameter	Frequency	Sampling Methodology
San Luis Drain	A	inflow to SLD	water quality of inflow	Se, B, EC	weekly composite	auto-sampler
				EC, TSS	weekly	mid-channel, depth integrated
	B	discharge from SLD	water quality of discharge (for Se load calculation)	Se, B, EC	daily composite	auto-sampler
				pH, EC, Temp, Se, B, TSS[1], Mo[2], Nutrients[3]	weekly	mid-channel, depth integrated
Mud Slough (north)	C	upstream of SLD discharge	Mud Slough (north) base water quality prior to receiving drainage discharges	pH, EC, Temp, Se, B, Mo[2], Nutrients[3]	weekly	grab
	D	downstream of discharge	Mud Slough (north) water quality as impacted by drainage discharge	pH, EC, Temp, Se, B, Mo[2], Nutrients[3]	weekly	mid-channel, depth integrated
	I/I2	back water	water quality impact of Mud Slough (north) flooding in Kesterson Refuge	Se, B, EC	annually	N/A
Wetland Channels	F	Salt Slough	water quality of habitat and to track improvements in former drainage conveyance channel	pH, EC, Temp, Se, B, Mo[2], Nutrients[3]	weekly	grab
	J	Camp 13	verify no discharge of drainage provision, water quality of wetland water supply channel	Se, B, EC	weekly	grab
	K	Agatha Canal	verify no discharge of drainage provision, water quality of wetland water supply channel	Se, B, EC	weekly	grab
	L2	San Luis Canal	water quality of wetland water supply channel	Se, B, EC	weekly	grab
	M2	Santa Fe Canal	water quality of wetland water supply channel	Se, B, EC	weekly	grab
San Joaquin River	G	at Fremont Ford (upstream of drainage inflow)	track improvements in former drainage conveyance channel and characterize water quality of habitat	pH, EC, Temp, Se, B, Mo[2], Nutrients[3]	weekly	grab
	H	at Hill's Ferry (downstream of drainage inflow)	intended to represent water quality of river most impacted by drainage discharge	Se, B, EC	monthly	grab
	N	at Crows Landing (downstream of Merced River confluence)	characterize water quality of habitat	Se, B, EC	daily composite	auto-sampler
				pH, EC, Temp, Se, B, Mo[2], Nutrients[3]	weekly	grab

Notes:

1 TSS required daily during storm events
2 Molybdenum required monthly
3 Nutrients required monthly September through February and every other week March through August

Table 2. Summary of Selenium Water Quality Objectives and Compliance Time Schedule

[Selenium Water Quality Objectives (in bold) and Performance Goals (in italics)]

Water Body/Water Year Type[1]	1 October, 1996	1 October, 2002	1 October, 2005	1 October, 2010
Salt Slough and Wetland Channels listed in Appendix 40 of Basin Plan	**2 µg/L monthly mean**			
San Joaquin River below the Merced River; Above Normal, and Wet Water Year Types		*5 µg/L monthly mean*	**5 µg/L 4-day average**	
San Joaquin River below the Merced River; Critical, Dry, and Below Normal Water Year Types		*8 µg/L monthly mean*	*5 µg/L monthly mean*	**5 µg/L 4-day average**
Mud Slough (north) and the San Joaquin River from Sack Dam to the Merced River				**5 µg/L 4-day average**

[1] The water year classification will be established using the best available estimate of the 60-20-20 San Joaquin Valley water year hydrologic classification (as defined in Footnote17 for Table 3 in the State Water Resources Control Board's *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*, May 1995) at the 75% exceedance level using data from the Department of Water Resources Bulletin 120 series. The previous water year's classification will apply until an estimate is made of the current water year.

Table 3. Boron Concentrations in the Grassland Watershed and San Joaquin River: January 2004 - December 2004

Station		Mean Monthly Concentration (mg/L)														Monthly
ID	Description	Jan-04	Feb-04	Mar-04		Apr-04	May-04	Jun-04	Jul-04	Aug-04	Sep-04		Oct-04	Nov-04	Dec-04	WQO
C	Mud Slu (N) upstrm of SLD Discharge	a	a	a	2.4	2.6	1.3	1.5	1.3	1.4	0.8	a	a	a	a	2.0
D	Mud Slu (N) dwnstrm of SLD Discharge	a	a	a	4.2	5.8	4.5	6.2	5.3	5.9	4.9	a	a	a	a	2.0
F	Salt Slough at Lander Avenue	a	a	a	1.3	0.9	0.5	0.5	0.6	0.5	0.6	a	a	a	a	2.0
G	SJR at Fremont Ford	a	a	a	1.0	0.9	0.6	0.5	0.6	0.5	0.7	a	a	a	a	2.0
N	SJR at Crows Landing Weekly Grab Samples	1.0	1.1	1.3	1.2	0.9	0.6	1.1	1.3	1.1	1.1	0.9	0.5	0.7	0.9	1.0/0.8[1]
N	SJR at Crows Landing Daily Autosamples	1.0	1.1	1.0	1.4	0.9	0.6	1.1	1.3	1.1	1.1	0.8	0.6	0.7	0.8	1.0/0.8[1]

Notes:

[yellow] = water quality objective exceedance

WQO = water quality objective in mg/L

na = no data available

a = objective only applies 15 March through 15 September

[1] = 1.0 mg/L applies 16 September through 14 March

0.8 mg/L applies 15 March through 15 September

Table 4. Boron Concentrations in the Grassland Watershed and San Joaquin River: January 2005 - December 2005

Station		Mean Monthly Concentration (mg/L)														
ID	Description	Jan-05	Feb-05	Mar-05		Apr-05	May-05	Jun-05	Jul-05	Aug-05	Sep-05		Oct-05	Nov-05	Dec-05	WQO
C	Mud Slu (N) upstrm of SLD Discharge	a	a	a	2.0	2.1	1.5	1.2	1.2	1.2	0.6	a	a	a	a	2.0
D	Mud Slu (N) dwnstrm of SLD Discharge	a	a	a	4.1	5.0	5.3	4.7	5.7	5.5	4.0	a	a	a	a	2.0
F	Salt Slough at Lander Avenue	a	a	a	1.3	1.0	0.7	0.5	0.5	0.5	0.5	a	a	a	a	2.0
G	SJR at Fremont Ford	a	a	a	0.5	0.6	0.3	0.3	0.5	0.4	0.4	a	a	a	a	2.0
N	SJR at Crows Landing Weekly Grab Samples	0.5	0.8	1.0	0.8	0.4	0.3	0.3	0.5	0.5	0.5	0.3	0.5	0.6	0.6	1.0/0.8[1]
N	SJR at Crows Landing Daily Autosamples	0.5	0.8	1.0	0.9	0.3	0.2	0.3	0.5	0.5	0.5	0.3	0.4	0.7	0.6	1.0/0.8[1]

Notes:

[yellow] = water quality objective exceedance

WQO = water quality objective in mg/L

na = no data available

a = objective only applies 15 March through 15 September

[1] = 1.0 mg/L applies 16 September through 14 March

0.8 mg/L applies 15 March through 15 September

Table 5. Molybdenum Concentrations in the Grassland Watershed and San Joaquin River: January 2004 - December 2004

Station ID	Description	Jan-04	Feb-04	Mar-04	Apr-04	May-04	Jun-04	Jul-04	Aug-04	Sep-04	Oct-04	Nov-04	Dec-04	Monthly WQO
		Mean Monthly Concentration (ug/L)												
C	Mud Slu (N) upstrm of SLD Discharge	5.2	5.5	5.7	9.2	8.1	7.8	4.6	7.1	na	na	4.4	5.2	19.0
D	Mud Slu (N) dwnstrm of SLD Discharge	8.0	8.3	9.3	14.7	13.1	15.6	11.8	13.8	na	5.9	9.4	7.4	19.0
F	Salt Slough at Lander Avenue	6.6	5.7	5.6	6.9	7.3	2.7	5.7	4.7	na	2.6	3.4	5.8	19.0
G	SJR at Fremont Ford	7.6	6.1	6.9	10.1	na	5.4	5.7	5.3	na	2.4	3.7	5.4	19.0
N	SJR at Crows Landing Grab Samples	5.3	1.7	5.1	3.2	na	4.1	4.9	3.2	na	1.5	2.5	4.4	10.0

Notes:

[yellow box] = water quality objective exceedance

WQO = water quality objective in ug/L

na = no data available

Table 6. Molybdenum Concentrations in the Grassland Watershed and San Joaquin River: January 2005 - December 2005

Station		Mean Monthly Concentration (ug/L)												Monthly
ID	Description	Jan-05	Feb-05	Mar-05	Apr-05	May-05	Jun-05	Jul-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05	WQO
C	Mud Slu (N) upstrm of SLD Discharge	6.4	2.3	5.0	3.5	6.6	4.5	4.9	5.1	4.3	3.7	3.1	3.3	19.0
D	Mud Slu (N) dwnstrm of SLD Discharge	8.6	3.2	7.7	8.9	12.2	13.4	17.6	10.9	11.2	6.8	10.2	6.0	19.0
F	Salt Slough at Lander Avenue	9.2	7.6	5.7	3.3	5.2	2.9	4.1	2.2	3.3	2.2	2.9	4.8	19.0
G	SJR at Fremont Ford	3.5	2.9	2.2	3.9	na	<1.0	4.9	3.2	3.9	1.3	3.5	3.0	19.0
N	SJR at Crows Landing Grab Samples	4.0	3.1	1.7	1.1	1.3	<1.0	2.7	1.0	1.5	1.4	2.2	1.5	10.0

Notes:

= water quality objective exceedance

WQO = water quality objective in ug/L

na = no data available

Table 7. Nutrient Series Data, Site B, SLD at terminus (MER535)
January 2004 - December 2004

Parameter	Nitrate	Total Kjeldhal Nitrogen	Total Phosphorus	Ortho Phosphate	Dissolved Ammonia	Ammonia Toxicity Threshold
Units	mg/L as N	mg/L	mg/L	mg/L as P	mg/L as N	mg/L as N
1/29/2004	28.9	0.7	0.07	0.01	0.06	2.72
2/26/2004	22.4	0.8	0.14	0.02	NA	NA
3/11/2004	19.4	1.2	0.09	<0.01	0.09	1.14
3/25/2004	22.4	1.2	0.12	<0.01	0.04	0.80
4/15/2004	18.6	1.2	0.10	0.01	0.08	1.18
4/29/2004	18.1	1.6	0.10	0.01	0.10	0.69
5/13/2004	14.4	1.7	0.10	<0.01	0.12	0.90
6/10/2004	15.9	1.7	0.07	<0.01	0.07	0.65
6/24/2004	10.8	2.0	0.10	<0.01	0.06	0.80
7/15/2004	14.2	1.6	<0.02	<0.01	0.08	1.33
7/29/2004	7.14	2.1	0.13	<0.03	NA	NA
8/12/2004	6.31	1.8	1.10	<0.03	0.05	0.63
8/26/2004	6.94	2.0	0.14	0.01	NA	NA
9/16/2004	8.44	1.9	0.14	<0.03	0.06	1.13
9/30/2004	5.29	1.8	NA	<0.03	0.19	1.59
10/28/2004	8.86	1.4	0.08	0.08	NA	NA
11/23/2004	8.27	1.2	0.11	0.01	NA	NA
12/29/2004	9.68	0.8	0.10	0.01	0.13	3.90

Data Source: California Regional Water Quality Control Board, Central Valley Region

Table 8. Nutrient Series Data, Site B, SLD at terminus (MER535)

January 2005 - December 2005

Parameter Units	Nitrate mg/L as N	Total Kjeldhal Nitrogen mg/L	Total Phosphorus mg/L	Ortho Phosphate mg/L as P	Dissolved Ammonia mg/L as N	Ammonia Toxicity Threshold mg/L as N
1/27/2005	23.7	0.8	0.15	0.02	0.13	2.69
2/24/2005	29.1	2.3	0.30	0.12	1.00	3.04
3/31/2005	33.1	1.0	0.09	<0.03	0.06	2.72
4/28/2005	16.2	2.1	NA	0.01	0.13	2.81
5/12/2005	23.0	NA	0.14	<0.03	NA	NA
5/26/2005	14.6	1.6	0.12	<0.03	0.08	0.92
6/16/2005	NA	1.3	NA	NA	NA	NA
6/30/2005	11.9	2.0	0.13	0.02	0.13	0.55
7/13/2005	11.8	2.0	NA	<0.03	NA	NA
7/28/2005	10.6	1.8	0.06	<0.03	NA	NA
8/11/2005	11.4	2.0	NA	<0.03	0.18	0.60
8/25/2005	11.6	1.8	0.10	NA	NA	NA
9/15/2005	5.55	2.0	NA	<0.03	NA	NA
9/29/2005	7.34	2.5	NA	<0.03	NA	NA
10/27/2005	6.60	1.7	NA	<0.05	NA	NA
11/22/2005	11.6	0.9	NA	<0.05	NA	NA
12/29/2005	14.8	1.1	0.07	<0.05	NA	NA

Data Source: California Regional Water Quality Control Board, Central Valley Region

Table 9. Nutrient Series Data, Site C, Mud Slough (North) Upstream of SLD (MER536)

January 2004 - December 2004

Parameter	Nitrate	Total Kjeldhal Nitrogen	Total Phosphorus	Ortho Phosphate	Dissolved Ammonia	Ammonia Toxicity Threshold
Units	mg/L as N	mg/L	mg/L	mg/L as P	mg/L as N	mg/L as N
1/29/2004	0.26	1.2	0.29	0.20	0.18	2.65
2/26/2004	0.94	1.6	0.43	0.32	NA	NA
3/11/2004	2.91	1.4	0.41	0.39	0.09	2.34
3/25/2004	0.90	1.9	0.83	0.63	0.30	1.77
4/15/2004	0.79	1.2	0.37	0.22	0.10	1.57
4/29/2004	<0.05	1.6	0.33	0.10	0.11	1.35
5/13/2004	0.54	1.0	0.37	0.06	0.16	1.51
6/10/2004	0.08	0.9	0.23	0.16	0.06	0.72
6/24/2004	<0.05	0.8	0.22	0.07	0.03	1.5
7/15/2004	0.62	0.5	0.03	0.02	0.06	1.44
7/29/2004	1.57	1.0	0.15	0.01	NA	NA
8/12/2004	NA	NA	NA	NA	NA	NA
8/26/2004	<0.16	1.4	0.44	0.28	NA	NA
9/16/2004	<0.16	1.7	0.43	0.10	0.19	2.21
9/30/2004	0.13	1.1	NA	0.10	0.22	2.55
10/28/2004	NA	NA	NA	NA	NA	NA
11/23/2004	0.10	1.3	0.34	0.24	NA	NA
12/29/2004	0.37	1.0	0.24	0.16	0.09	3.18

Data Source: California Regional Water Quality Control Board, Central Valley Region

Table 10. Nutrient Series Data, Site C, Mud Slough (North) Upstream of SLD (MER536)

January 2005 - December 2005

Parameter	Nitrate	Total Kjeldhal Nitrogen	Total Phosphorus	Ortho Phosphate	Dissolved Ammonia	Ammonia Toxicity Threshold
Units	mg/L as N	mg/L	mg/L	mg/L as P	mg/L as N	mg/L as N
1/27/2005	0.46	1.4	0.43	0.26	0.36	2.95
2/24/2005	0.29	1.3	0.54	0.29	0.30	2.84
3/31/2005	0.40	1.8	0.57	0.39	0.18	2.16
4/28/2005	0.52	1.3	NA	0.17	0.36	2.06
5/12/2005	0.07	NA	0.34	0.04	NA	NA
5/26/2005	0.12	1.1	0.28	0.13	0.06	1.56
6/16/2005	NA	0.8	NA	NA	NA	NA
6/30/2005	1.43	1.0	0.27	0.11	0.09	0.81
7/13/2005	0.53	0.8	NA	0.04	NA	NA
7/28/2005	0.22	1.2	0.20	0.03	NA	NA
8/11/2005	0.32	1.0	NA	<0.03	0.23	0.55
8/25/2005	0.05	1.2	0.27	NA	NA	NA
9/15/2005	0.15	1.2	NA	0.06	NA	NA
9/29/2005	<0.05	1.2	NA	0.13	NA	NA
10/27/2005	0.07	1.5	NA	0.47	NA	NA
11/22/2005	0.16	1.2	NA	0.28	NA	NA
12/29/2005	0.17	1.2	0.40	0.29	NA	NA

Data Source: California Regional Water Quality Control Board, Central Valley Region

Table 11. Nutrient Series Data, Site D, Mud Slough (North) Downstream of SLD (MER542)

January 2004 - December 2004

Parameter Units	Nitrate mg/L as N	Total Kjeldhal Nitrogen mg/L	Total Phosphorus mg/L	Ortho Phosphate mg/L as P	Dissolved Ammonia mg/L as N	Ammonia Toxicity Threshold mg/L as N
1/29/2004	3.93	1.2	0.26	0.17	0.15	2.65
2/26/2004	6.64	1.4	0.35	0.28	NA	NA
3/11/2004	4.00	2.1	0.55	0.30	0.20	2.74
3/25/2004	7.73	1.8	0.58	0.23	0.23	1.52
4/15/2004	9.53	1.7	0.22	0.03	0.08	1.32
4/29/2004	10.9	1.9	0.16	<0.01	0.11	0.95
5/13/2004	6.76	1.6	0.24	<0.01	0.14	0.94
6/10/2004	13.1	1.7	0.12	<0.01	0.06	0.66
6/24/2004	8.89	1.8	0.12	<0.01	0.06	0.84
7/15/2004	8.20	1.2	0.07	<0.01	0.10	1.26
7/29/2004	5.09	1.7	0.13	<0.03	NA	NA
8/12/2004	6.27	1.8	0.10	<0.03	0.06	0.68
8/26/2004	6.12	2.1	0.18	<0.03	NA	NA
9/16/2004	4.33	1.8	0.22	<0.03	0.15	1.33
9/30/2004	1.75	1.6	NA	<0.03	0.30	2.46
10/28/2004	1.35	1.5	0.35	0.38	NA	NA
11/23/2004	1.53	1.5	0.28	0.20	NA	NA
12/29/2004	1.36	1.1	0.22	0.12	0.05	3.3

Data Source: California Regional Water Quality Control Board, Central Valley Region

Table 12. Nutrient Series Data, Site D, Mud Slough (North) Downstream of SLD (MER542)

January 2005 - December 2005

Parameter	Nitrate	Total Kjeldhal Nitrogen	Total Phosphorus	Ortho Phosphate	Dissolved Ammonia	Ammonia Toxicity Threshold
Units	mg/L as N	mg/L	mg/L	mg/L as P	mg/L as N	mg/L as N
1/27/2005	6.04	1.4	0.41	0.20	0.24	2.84
2/24/2005	4.87	1.5	0.45	0.26	0.14	3.03
3/31/2005	10.4	1.7	0.43	0.20	0.19	1.94
4/28/2005	7.46	1.5	NA	0.03	0.17	1.67
5/12/2005	11.9	NA	0.25	<0.03	NA	NA
5/26/2005	4.72	1.5	0.20	<0.03	0.07	0.89
6/16/2005	NA	1.2	NA	NA	NA	NA
6/30/2005	6.82	1.8	0.16	0.01	0.12	0.64
7/13/2005	5.57	1.5	NA	<0.03	NA	NA
7/28/2005	6.52	1.7	0.10	<0.03	NA	NA
8/11/2005	6.70	2.1	NA	<0.03	0.21	0.55
8/25/2005	8.31	1.8	0.14	NA	NA	NA
9/15/2005	2.15	1.5	NA	<0.03	NA	NA
9/29/2005	2.29	1.6	NA	<0.03	NA	NA
10/27/2005	0.74	1.4	NA	0.35	NA	NA
11/22/2005	1.91	1.3	NA	0.20	NA	NA
12/29/2005	1.49	1.5	0.33	0.26	NA	NA

Data Source: California Regional Water Quality Control Board, Central Valley Region

Table 13. Nutrient Series Data, Site G, San Joaquin River at Fremont Ford (MER538)

January 2004 - December 2004

Parameter	Nitrate	Total Kjeldhal Nitrogen	Total Phosphorus	Ortho Phosphate	Dissolved Ammonia	Ammonia Toxicity Threshold
Units	mg/L as N	mg/L	mg/L	mg/L as P	mg/L as N	mg/L as N
1/29/2004	0.56	0.8	0.22	0.10	0.12	3.03
2/26/2004	3.74	1.0	0.31	0.21	NA	NA
3/11/2004	0.76	1.9	0.66	0.19	0.23	2.36
3/25/2004	2.08	1.1	0.34	0.20	0.09	1.99
4/15/2004	1.04	1.2	0.41	0.27	0.17	1.99
4/29/2004	0.79	1.4	0.30	0.10	0.08	1.65
5/13/2004	1.03	1.0	0.40	0.26	0.12	2.16
6/10/2004	2.63	1.3	0.38	0.22	0.08	1.72
6/24/2004	2.22	1.4	0.46	0.17	0.08	1.51
7/15/2004	1.58	0.9	0.41	0.18	0.08	2.33
8/26/2004	0.72	1.1	0.36	0.14	NA	NA
9/16/2004	0.24	0.8	0.36	0.14	0.08	2.23
9/30/2004	0.07	0.7	NA	0.10	0.09	2.21
10/28/2004	0.27	1.2	0.35	0.44	NA	NA
11/23/2004	0.51	1.0	0.26	0.16	NA	NA
12/29/2004	0.42	1.0	0.37	0.18	0.10	3.26

Data Source: California Regional Water Quality Control Board, Central Valley Region

Table 14. Nutrient Series Data, Site G, San Joaquin River at Fremont Ford (MER538)

January 2005 - December 2005

Parameter	Nitrate	Total Kjeldhal Nitrogen	Total Phosphorus	Ortho Phosphate	Dissolved Ammonia	Ammonia Toxicity Threshold
Units	mg/L as N	mg/L	mg/L	mg/L as P	mg/L as N	mg/L as N
1/27/2005	1.79	1.0	0.37	0.27	0.25	4.94
2/24/2005	1.66	0.9	0.35	0.25	0.10	5.72
3/31/2005	0.72	0.8	0.30	0.19	0.12	5.39
4/28/2005	0.95	1.5	NA	0.38	0.27	4.56
5/12/2005	0.71	NA	0.32	0.19	NA	NA
5/26/2005	NA	NA	NA	NA	NA	NA
6/16/2005	NA	0.7	NA	NA	NA	NA
6/30/2005	0.66	0.6	0.18	0.09	0.09	2.42
7/13/2005	1.44	0.9	NA	0.20	NA	NA
7/28/2005	1.69	1.1	0.44	0.26	NA	NA
8/11/2005	1.62	0.9	NA	0.21	0.13	1.30
8/25/2005	1.39	1.0	0.51	NA	NA	NA
9/15/2005	0.36	1.0	NA	0.16	NA	NA
9/29/2005	0.42	0.9	NA	0.16	NA	NA
10/27/2005	0.33	0.8	NA	0.16	NA	NA
11/22/2005	0.66	0.8	NA	0.16	NA	NA
12/29/2005	0.54	1.0	0.27	0.14	NA	NA

Data Source: California Regional Water Quality Control Board, Central Valley Region

Table 15. Nutrient Series Data, Site N, San Joaquin River at Crows Landing (STC504)

January 2004 - December 2004

Parameter Units	Nitrate mg/L as N	Total Kjeldhal Nitrogen mg/L	Total Phosphorus mg/L	Ortho Phosphate mg/L as P	Dissolved Ammonia mg/L as N	Ammonia Toxicity Threshold mg/L as N
1/29/2004	2.12	0.8	0.19	0.09	0.12	2.91
2/26/2004	2.83	1.5	0.31	0.12	NA	NA
3/11/2004	2.89	1.3	0.39	0.18	0.10	2.31
3/25/2004	3.41	1.0	0.37	0.21	0.05	1.78
4/15/2004	2.21	0.7	0.22	0.14	0.04	2.21
4/29/2004	1.38	0.6	0.15	0.06	0.05	1.99
5/13/2004	1.27	0.5	0.17	0.09	0.06	2.57
6/10/2004	4.53	1.2	0.25	0.07	0.04	0.95
6/24/2004	3.05	1.5	0.33	0.07	0.05	1.20
7/15/2004	3.06	1.5	0.31	0.03	0.06	0.85
7/29/2004	4.24	1.5	0.38	0.13	NA	NA
8/12/2004	2.50	1.1	0.31	0.12	0.09	1.18
8/26/2004	2.15	1.2	0.30	<0.03	NA	NA
9/16/2004	3.14	0.9	0.28	0.07	0.05	2.56
9/30/2004	2.85	0.6	NA	0.08	0.09	2.29
10/28/2004	1.48	0.9	0.24	0.26	NA	NA
11/23/2004	1.83	0.9	0.21	0.14	NA	NA
12/29/2004	1.48	0.8	0.20	0.11	0.04	3.03

Data Source: California Regional Water Quality Control Board, Central Valley Region

Table 16. Nutrient Series Data, Site N, San Joaquin River at Crows Landing (STC504)

January 2005 - December 2005

Parameter Units	Nitrate mg/L as N	Total Kjeldhal Nitrogen mg/L	Total Phosphorus mg/L	Ortho Phosphate mg/L as P	Dissolved Ammonia mg/L as N	Ammonia Toxicity Threshold mg/L as N
1/27/2005	2.65	1.0	0.37	0.22	0.17	4.13
2/24/2005	1.83	1.1	0.41	0.26	0.10	4.77
3/31/2005	0.73	0.6	0.17	0.10	0.09	4.48
4/28/2005	1.25	0.6	NA	0.13	0.07	4.04
5/12/2005	0.91	NA	0.20	0.08	NA	NA
5/26/2005	0.18	0.5	0.17	0.10	0.05	2.26
6/16/2005	NA	0.3	NA	NA	NA	NA
6/30/2005	1.03	0.5	0.18	0.06	0.13	2.62
7/13/2005	1.17	0.6	NA	0.06	NA	NA
7/28/2005	1.92	0.7	0.22	0.11	NA	NA
8/11/2005	2.22	0.6	NA	0.08	0.03	1.43
8/25/2005	1.89	0.5	0.18	NA	NA	NA
9/15/2005	1.55	0.6	NA	0.08	NA	NA
9/29/2005	1.49	0.5	NA	0.06	NA	NA
10/27/2005	1.90	0.6	NA	0.15	NA	NA
11/22/2005	2.02	0.8	NA	0.15	NA	NA
12/29/2005	0.40	0.7	0.19	0.08	NA	NA

Data Source: California Regional Water Quality Control Board, Central Valley Region

Figure 1. Selenium Concentration in the San Joaquin River
January 2004 - December 2004

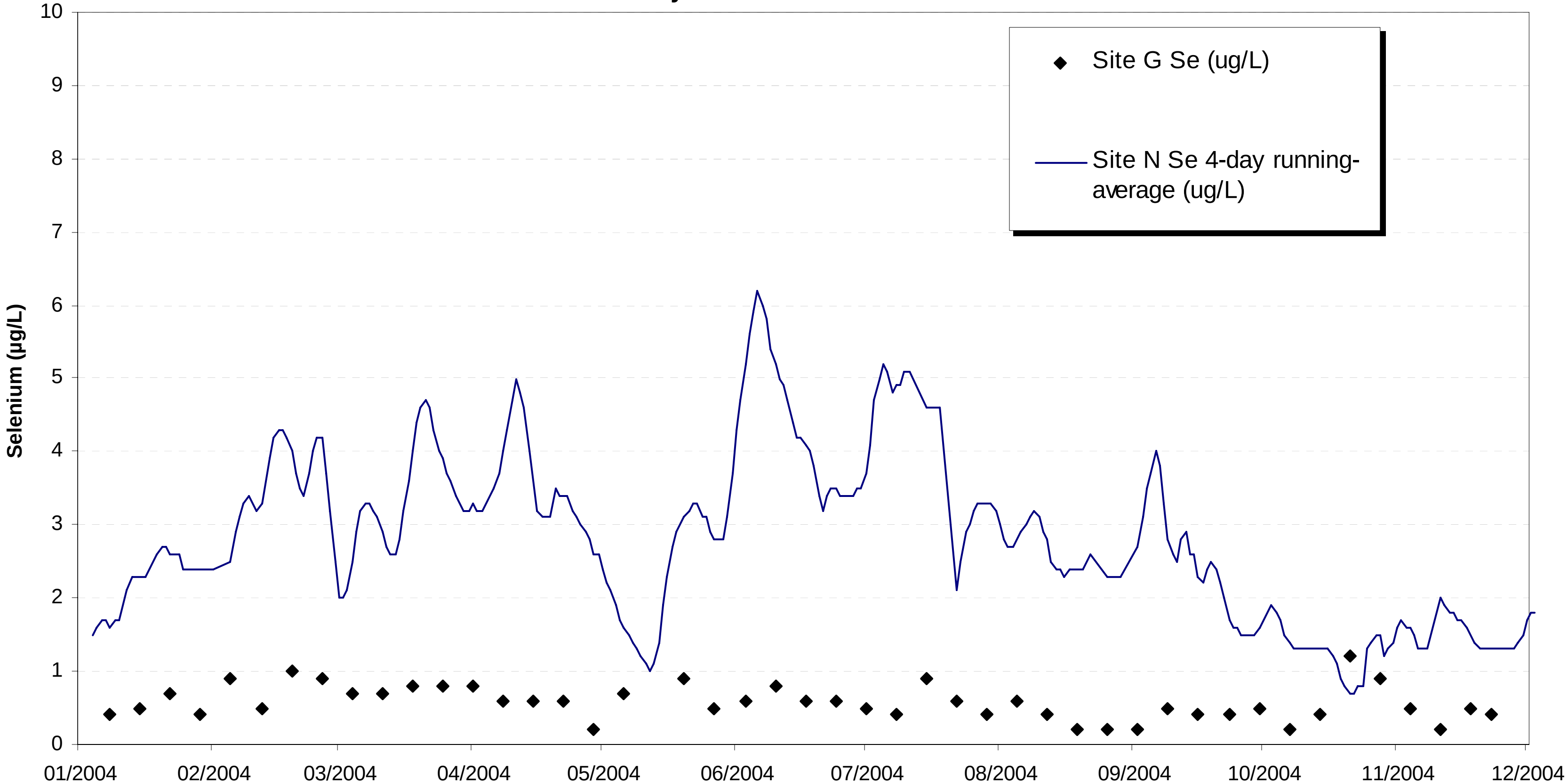

Figure 2. Selenium Concentration in the San Joaquin River
January 2005 - December 2005

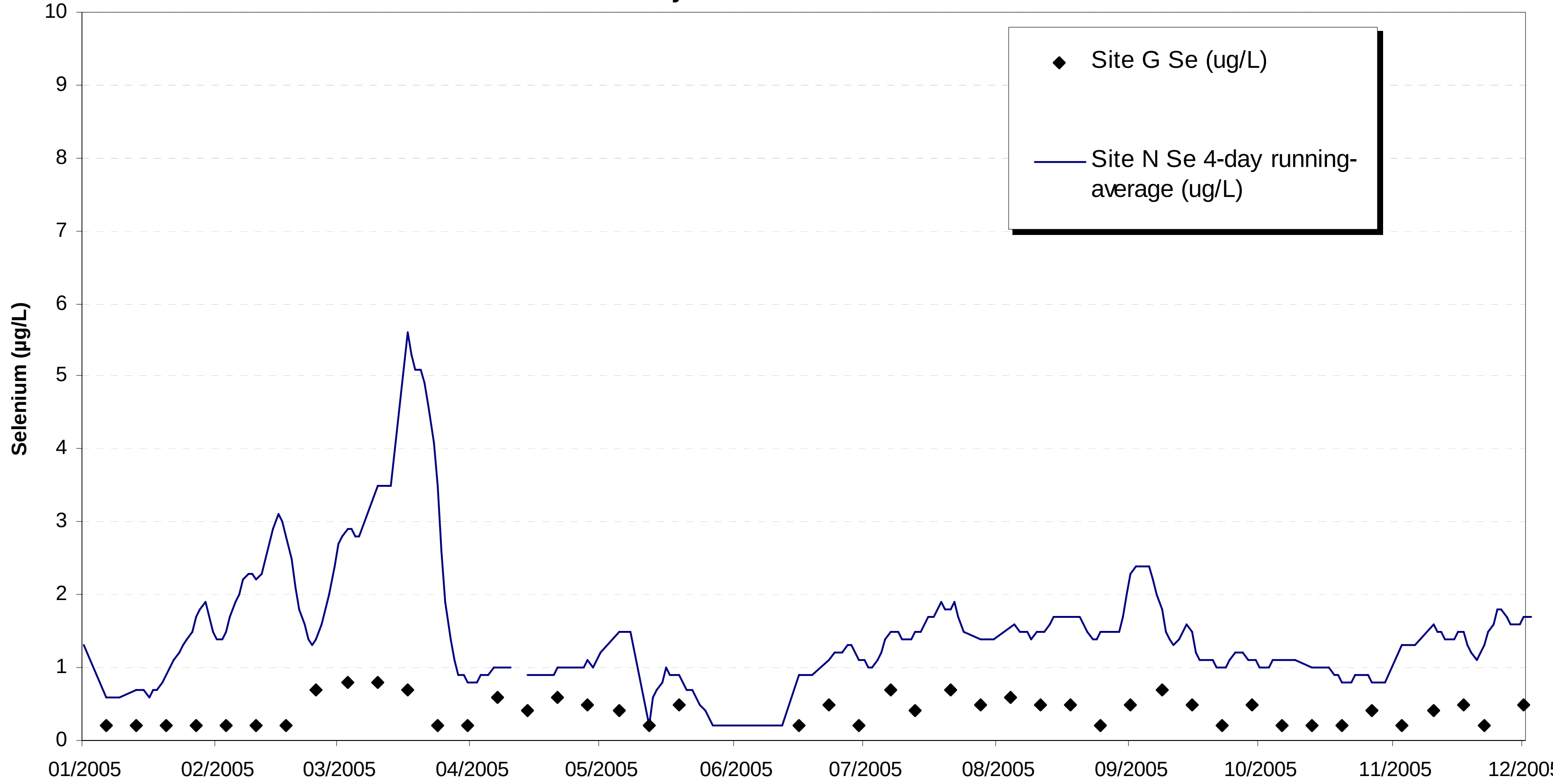

Figure 3. Monthly Mean Selenium Concentration at Site N
January 2004 - December 2004

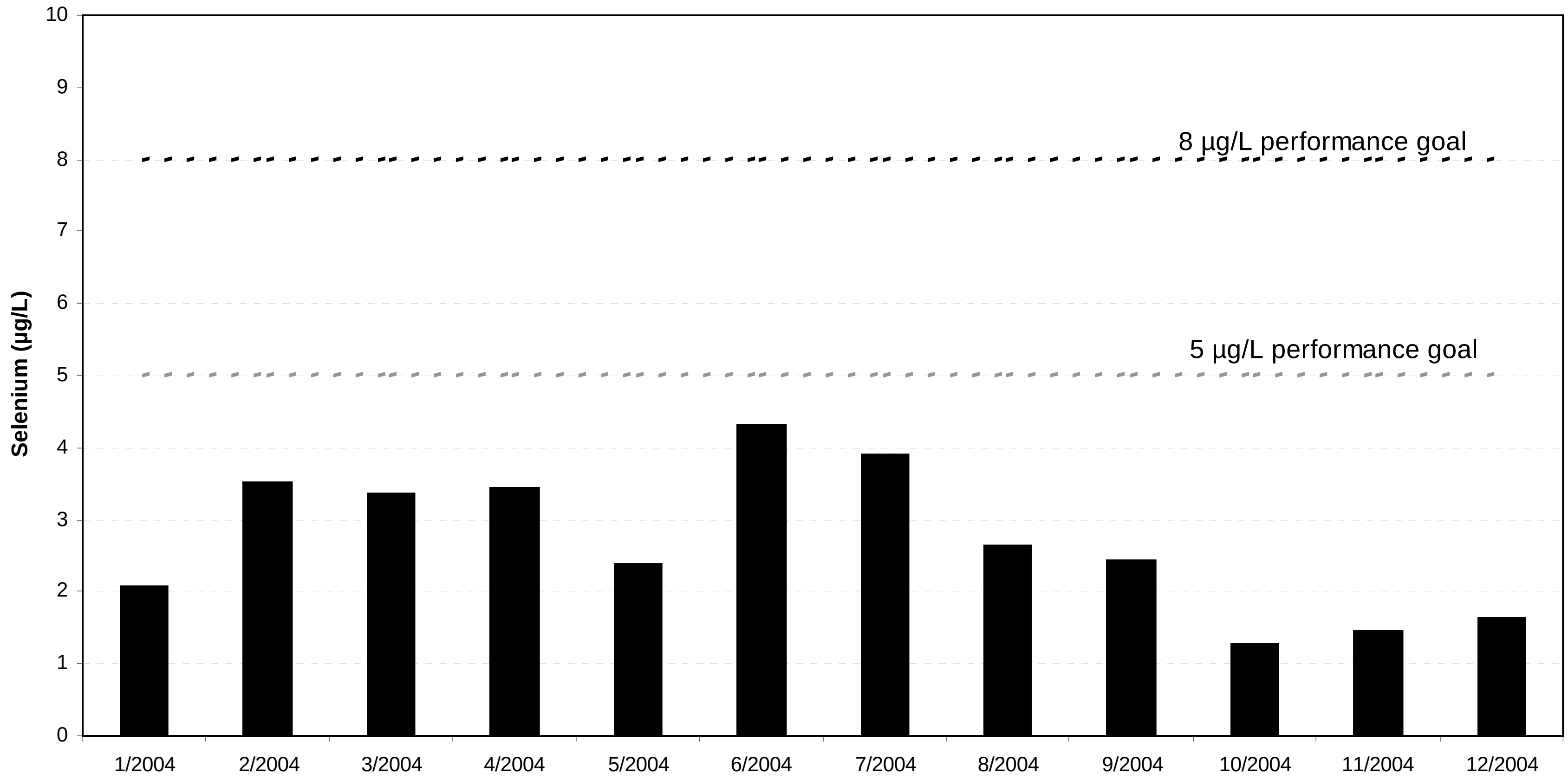

Figure 4. Monthly Mean Selenium Concentration at Site N
January 2005 - December 2005

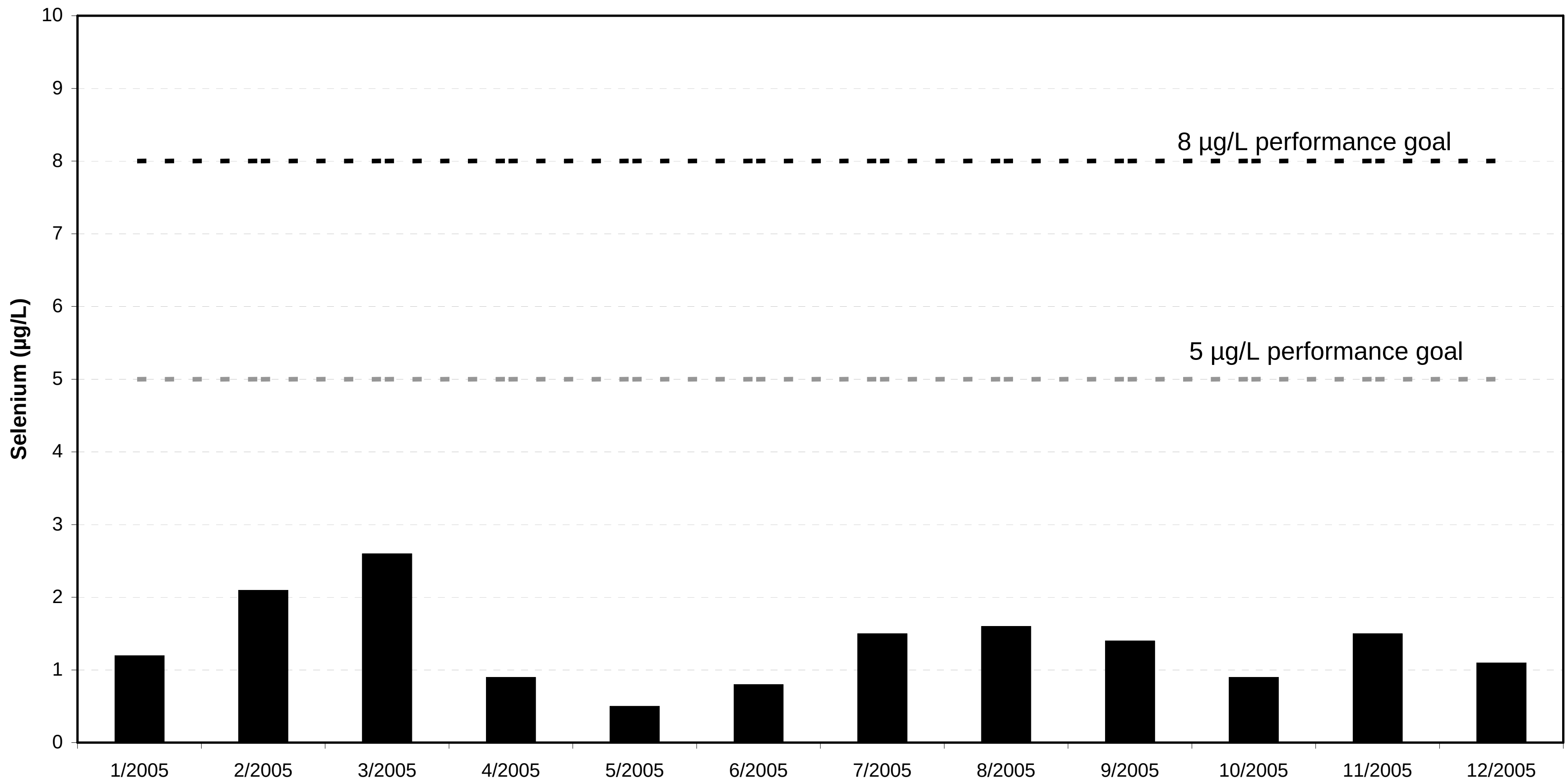

Figure 5. Mean Monthly Selenium Concentration in the Grassland Wetland Supply Channels
January 2004 - December 2004

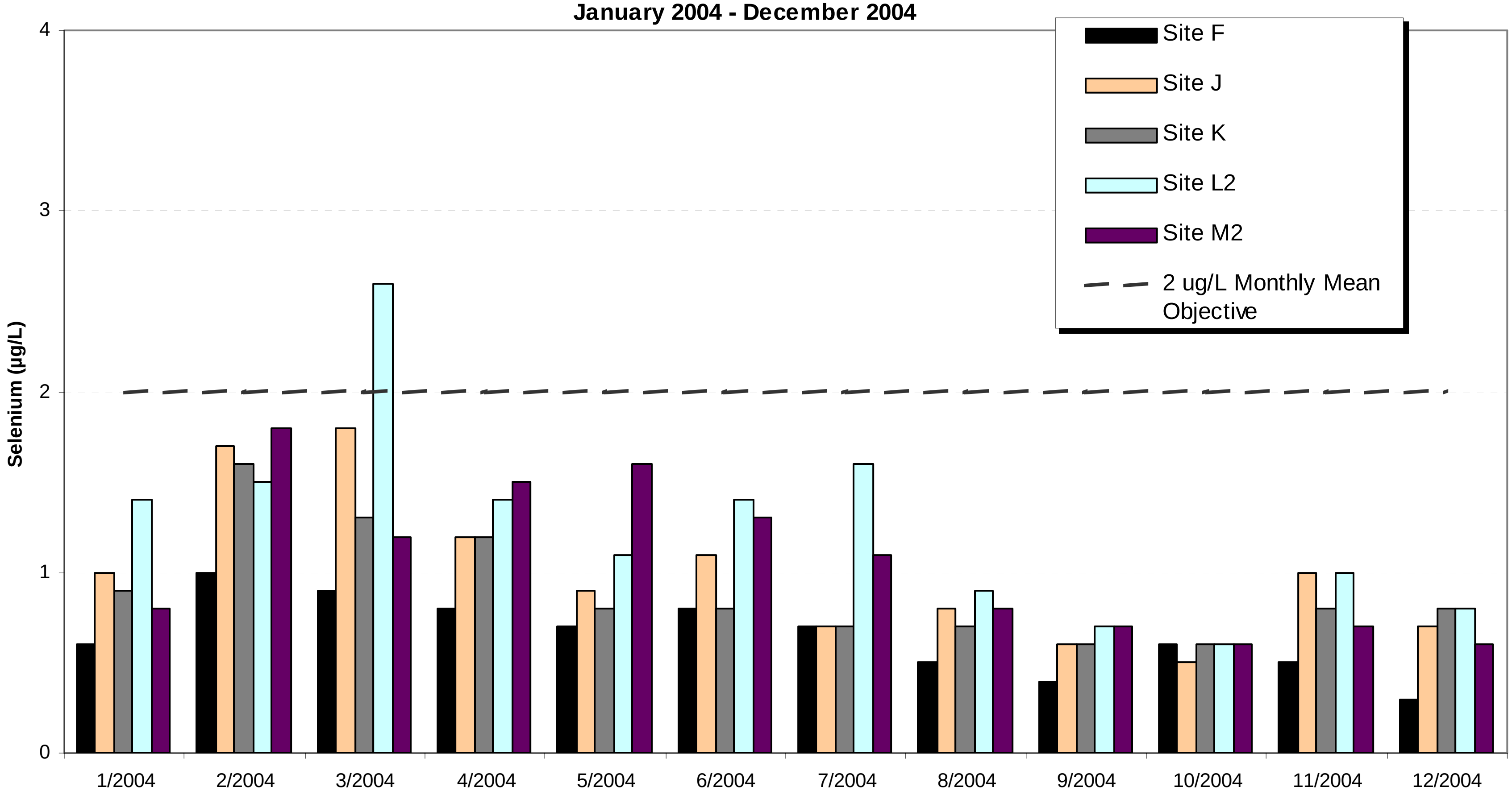

Figure 6. Mean Monthly Selenium Concentration in the Grassland Wetland Supply Channels
January 2005 - December 2005

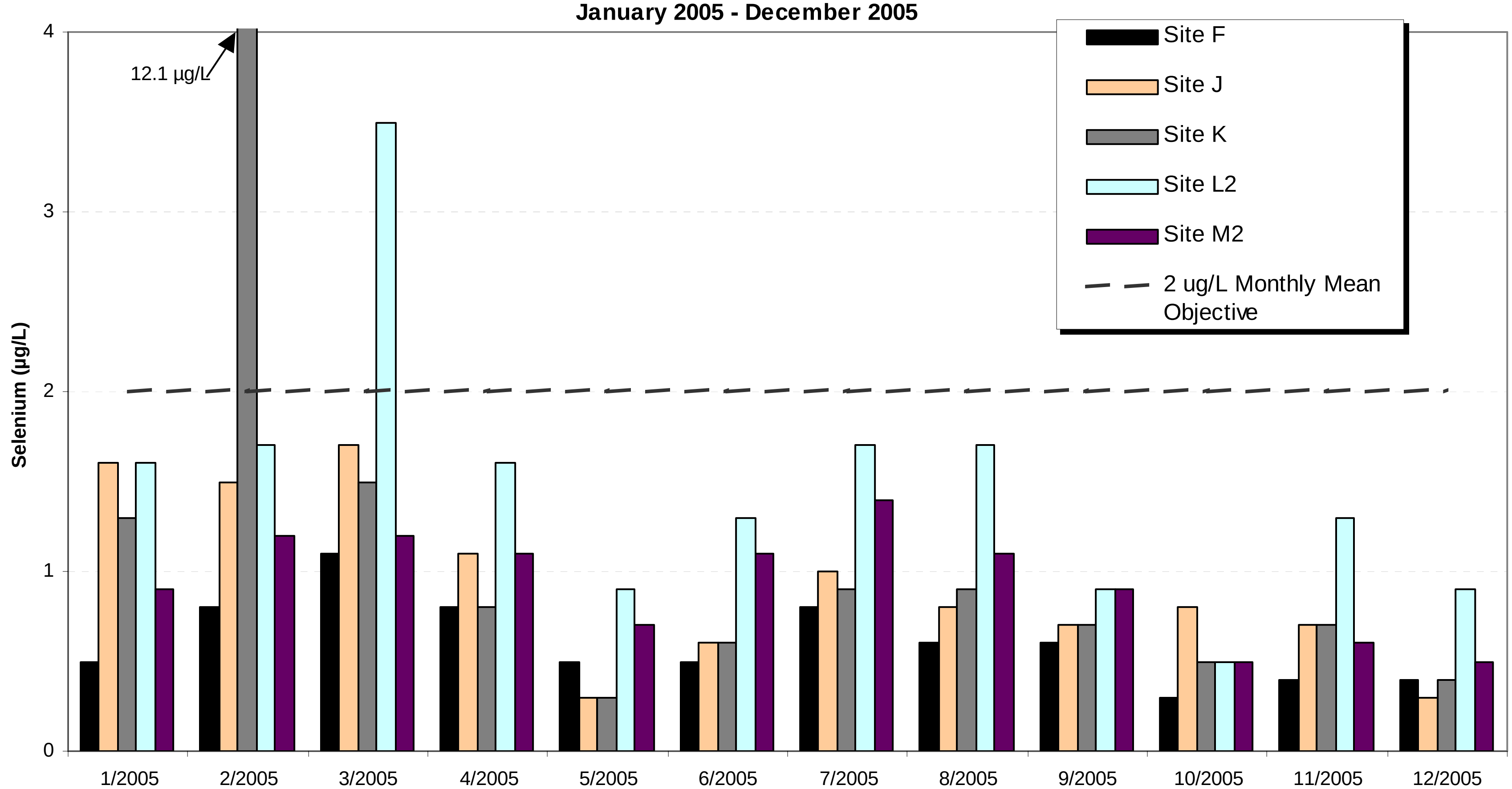

Figure 7. Weekly Grab Selenium Concentration at Site D
January 2004 - December 2004

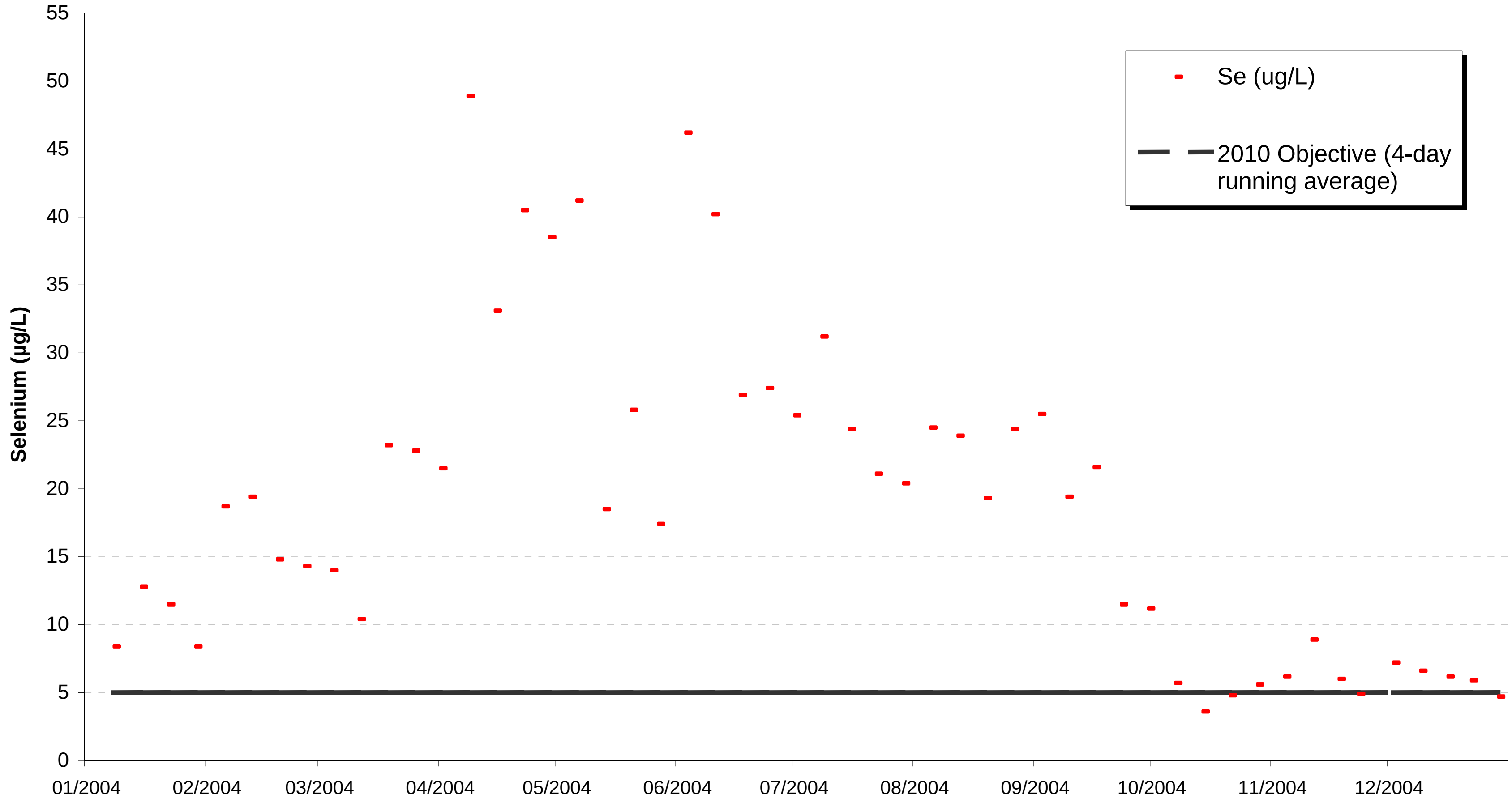

Figure 8. Weekly Grab Selenium Concentration at Site D
January 2005 - December 2005

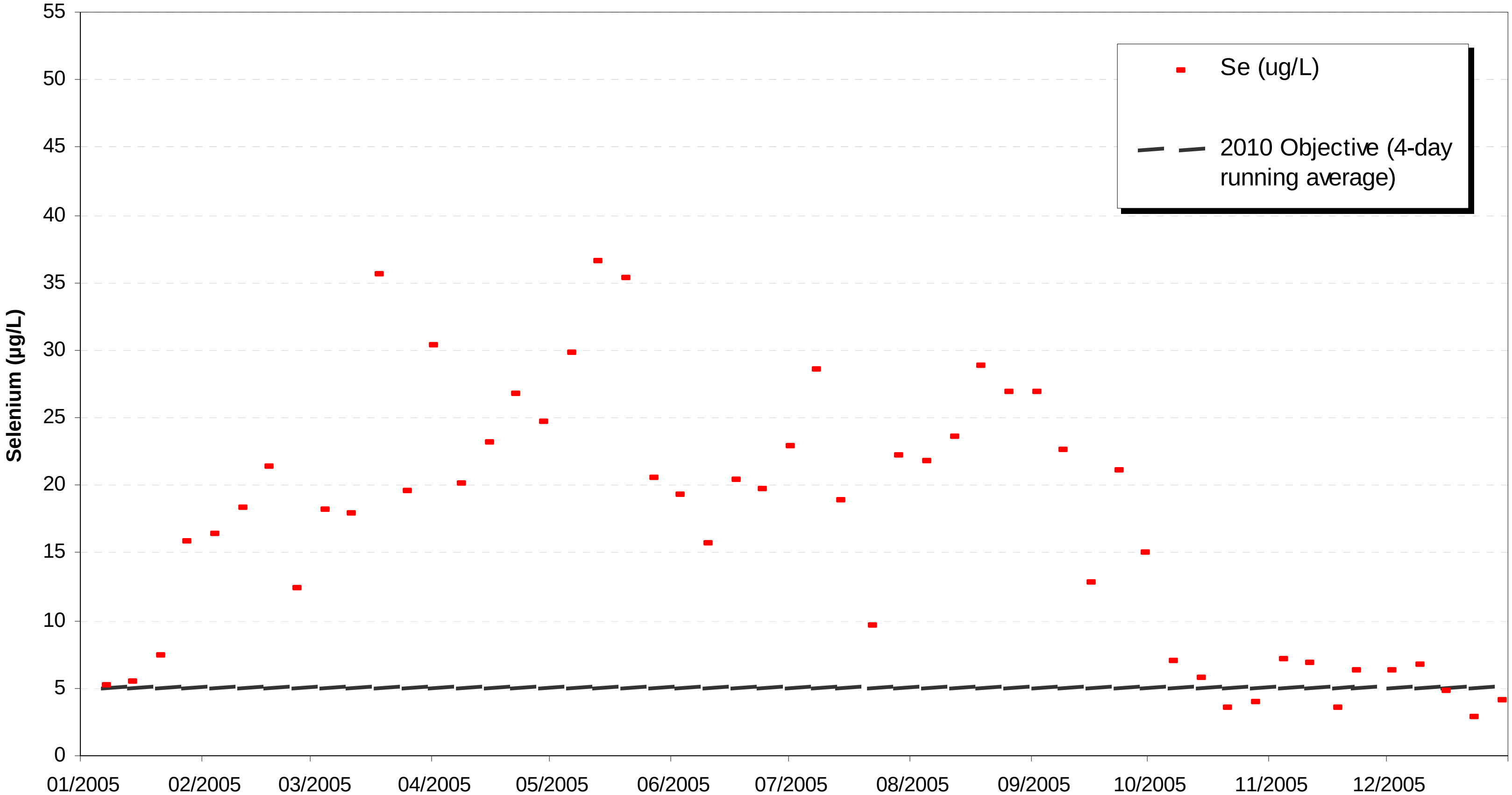

Figure 9. Weekly Grab Selenium Concentration at Site C
January 2004 - December 2004

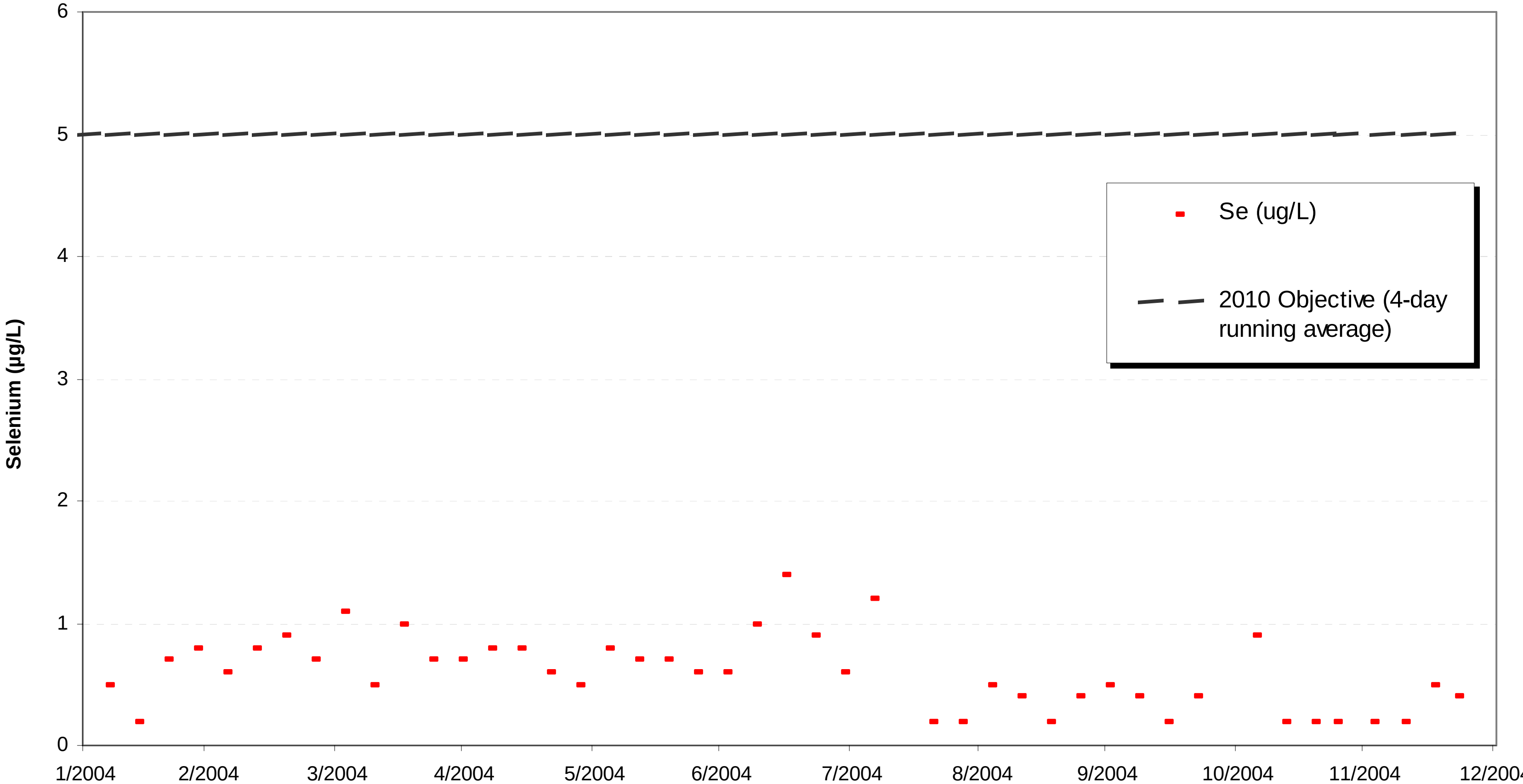

Figure 10. Weekly Grab Selenium Concentration at Site C
January 2005 - December 2005